Winter-active wolf spiders (Araneae: Lycosidae) in thermal habitats from western Romania

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Shores of channels with thermal water provide an adequate microclimate for maintaining wolf spiders in activity during winter. Of the spiders collected after the winter survey of 22 thermal habitats from western Romania, 93.02% were juveniles and subadults, while the remaining individuals belonged to the following seven species: *Arctosa leopardus*, *Pardosa amentata*, *Pardosa proxima*, *Pirata piraticus*, *Piratula latitans*, *Trochosa robusta* and *Trochosa ruricola*. The reproductive period of some species is altered under the influence of neighbouring hot waters, as revealed by the capture of females with egg sacs and spiderlings, during winter.

Keywords: wolf spiders; reproduction; winter; hot springs; Romania

Introduction

Most spiders spend the cold periods of winters in temperate regions in a certain type of diapause (e.g. juvenile or adult diapause, see in: Schaefer 1977), taking shelter under tree bark (Horváth et al. 2004), in burrows (Framenau et al. 1996), or leaf litter (Edgar 1971). However, if the environmental conditions become suitable (Huhta and Viramo 1979) they can leave these shelters, winter activity being a fairly widespread phenomenon among spiders (e.g. Gunnarsson 1985; Vanin and Turchetto 2007), which may include feeding, reproduction and migration to new habitats (Hågvar and Aakra 2006; Hågvar 2010). A special place among these is held by the winter-mature species that only reproduce during the cold season (see in: Aitchison 1984; Schaefer 1987 and the references cited therein).

The Pannonian Basin is rich in geothermal water resources, used for heating, bathing, for medical purposes or in industry (Antal and Rosca 2008; Kulcsár 2012). The resulting wastewaters are sometimes discharged into channels, which together with those supplied directly by captured thermal springs have been shown to house non-hibernating populations of amphibians in many situations (e.g. Covaciu-Marcov et al. 2010, 2011c; Sas et al. 2012). Generally, in those habitats that persist for a longer time there have also been reported changes in the biology of these animals, such as wintertime breeding and the presence of larval gigantism (e.g. Covaciu-Marcov et al. 2003; Sas et al. 2009, 2010). In addition, the warm waters exert a

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certain influence also on the terrestrial invertebrates that inhabit the surrounding areas, as was shown, for instance, in isopods (Ferenți et al. 2013). Geothermal areas can harbour a diverse terrestrial invertebrate fauna (Boothroyd and Browne 2006) and the occurrence of spiders in such habitats has been reported previously (e.g. Sheppe 1975; Stark et al. 1976; Elmarsdottir et al. 2003), but without a discussion on the possible effects of these waters on their development. The present paper relates the Lycosidae species collected during winter in the vicinity of some thermal waters from western Romania and considers the influence of such waters on the growth and reproduction of these wolf spiders. It therefore also enlarges the knowledge about winter activity of spiders in Romania.

Material and methods

Study area

The studied area is situated in western Romania (47°33'–46°20' N, 22°43'–21°18' E). Twenty-two thermal habitats located inside or in the neighbourhood of 19 localities were investigated (Figure 1). Almost all habitats are channels supplied by hot water originating either directly from wells or representing wastewater discharged from swimming pools, factories, greenhouses or homes. Water temperature is over 55°C at the exit from wells, but is lower (14–40°C) in the case of the other sources. In some habitats (e.g. Săcuieni I and II, Chișlaz), the temperature at ground level of the banks, at an approximately 0.5–1 m distance from water, is 4–6°C. The habitat from Oradea is located inside the city and is represented by a small area with herbaceous vegetation moistened by hot wastewater before flowing into a stream. The other habitats are described in previous papers dealing with non-hibernating amphibian populations from them (see in: Covaciu-Marcov et al. 2006, 2010; Sas et al. 2007, 2009, 2012; Covaciu-Marcov et al. 2011a, 2011b, 2011c) and therefore we do not discuss them here in more detail.

Data collection

The study was conducted during two winter periods (December 2011–January 2012 and January–February 2013). Nine of the studied habitats were visited in both cold periods and six were surveyed twice during the winter of 2012–13. Wolf spiders were collected by hand on the banks of the channels from the grassy vegetation and preserved in 70% ethanol. Only those individuals that were actively moving were captured. Three life-stages have been identified: juveniles, subadults and adults (according to Pickavance 2001). Adult spiders were identified to species level, the nomenclature being according to Platnick (2013).

Results

Active wolf spiders were found in 21 investigated habitats, but not in both winters, the total number of collected individuals being 344 (on average 10.42 spiders/habitat/collection date). Most of them were juveniles and subadults, representing 93.02% of the total spiders collected. However, in 10 thermal habitats we found 24 adult individuals belonging to seven species: *Arctosa leopardus* (Sundewall, 1833),

Figure 1. Map of the surveyed localities with thermal habitats in western Romania (1, Moneasa; 2, Ciocaia; 3, Roşiori; 4, Roşiori/Tămăşeşu; 5, Săcuieni I; 6, Săcuieni II; 7, Curtici; 8, Socodor; 9, Chiribiş; 10, Chişlaz; 11, Livada de Bihor; 12, Mădăras; 13, Răbăgani; 14, Sănnicolau de Munte; 15, Tărian; 16, Acâş; 17, Beltiug; 18, Mihăieni; 19, Chiraleu; 20, Oradea; 21, Săcuieni III; 22, Tămăşeşu; AR = Arad county, BH = Bihor county, SM = Satu Mare county).

Pardosa amentata (Clerck, 1757), *Pardosa proxima* (C. L. Koch, 1847), *Pirata piraticus* (Clerck, 1757), *Piratula latitans* (Blackwall, 1841), *Trochosa robusta* (Simon, 1876) and *Trochosa ruricola* (De Geer, 1778) (Table 1). Half of the collected adult spiders were males and half were females.

The female of *Piratula latitans* collected in the thermal habitat from Mădăras in mid-January 2012 had a cocoon with 38 eggs. Of the three females of *Pirata piraticus*, two were captured in Livada de Bihor in mid-February 2013, one of them having a cocoon with 58 eggs and the other carrying spiderlings. *Pardosa proxima* and *Trochosa ruricola* were the most common species, being identified each in five

Table 1. Number of wolf spiders collected during winter months in different thermal habitats from western Romania (m = male, f = female, s = subadult, j = juvenile; localities: 1, Moneasa; 2, Ciociaia; 3, Roşiori; 4-, Roşiori/Tămăşeu; 5, Săcuieni I; 6, Săcuieni II; 7, Curtici; 8, Socodor; 9, Chiribiş; 10, Chişlaz; 11, Livada de Bihor; 12-Mădăras; 13-Răbăgani; 14-Sănnicolau de Munte; 15, Tărian; 16, Acâş; 17, Belciug; 1, Mihăteni; 19, Chiraleu; 20-Oradea; 21, Săcuieni III, see also [Figure 1](#)).

Species	Months/Localities																				
	XII										I										
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
<i>Arctosa</i> sp.			1sf					1sf	1sf	1j					1sf			2sf			
<i>Arctosa leopardus</i>																	1m				
<i>Aulonia</i> sp.		2sm		1sm														1sf			
<i>Pardosa</i> sp.	1sm		4j, 1sm, 2sf	3j, 3sm, 2sf	9j, 3sm, 8sf	5sm, 1sf	3sm, 10sf	13sf	1j, 2sf	1sf	9j, 37sm, 34sf	1j, 8sm, 3j, 1sm, 9sf	1sm	8j, 2sf	1sf	1sm	1j, 1sm, 2j, 4sm, 2sf	3j, 3sm, 3sf	1sm, 2sf	1sf	1j, 7sm, 4sf
<i>Pardosa amentata</i>																				2m	
<i>Pardosa proxima</i>																				1m	
<i>PratalPratula</i> sp.	3sm, 1sf		1sm	1sm	1sm, 1sf	1m	1f		1sm, 2sf	1sm	1j, 3sm, 2sf	3j, 1sm, 1j, 1sf	2j, 1sm, 1sf	4j, 1sm, 2sm	4j, 1sm, 2sf	1j	1j, 1sf			1sf	
<i>Pirata piraticus</i>										1f						2m					2f
<i>Pratula latians</i>												1f									
<i>Trochosa</i> sp.		1j	1j, 1sf		1sf				1sf			1j, 1sf						2j, 1sf	1j, 1sf		
<i>Trochosa robusta</i>																					
<i>Trochosa ruricola</i>					1f			1m				1m, 1f					1f			1f	

habitats, followed by *Pirata piraticus* present in four habitats, while the other species were found only in one habitat each. The highest number of wolf spiders was collected from Chişlaz, but species richness was highest in the habitat from Oradea.

Discussion

A special microclimate is created on the shores of the channels with warm water that allows spiders to remain active during winter. The best habitats are the channels with relatively high banks covered with herbaceous vegetation, in which the water flows and its temperature is sufficient to ensure a proper area for the activity of spiders and their potential prey. Such are the habitats from Săcuieni I and II, Chişlaz, where the number of collected spiders was high. However, the quality of a habitat is also important along with its conformation. The water of many wells is used by locals for washing, even of cars; this leads to pollution of the water and of the adjacent ground, with various chemical substances and with other waste products (Sas et al. 2009, 2012; Covaciu-Marcov et al. 2010, 2011b). The presence of certain pollutants in the environment can slow the development of spiders (Chen et al. 2011). Pollution might have been one of the causes of the low number of wolf spiders caught in some habitats (e.g. those from localities 2 and 19). All identified species occur solely or also in moist areas (Nørgaard 1951; Fuhn and Niculescu-Burlacu 1971; Vlijm 1971; Alderweireldt and Maelfait 1988; Fetykó 2008) and some species, like *Pardosa amentata*, are known to inhabit disturbed habitats also (Vlijm 1971).

Among lycosid species there are both stenochronous species that reproduce in spring and summer and diplochronous species that reproduce in spring and autumn (Schaefer 1977; Framenau et al. 1996). We have identified spiders with egg sacs and spiderlings in winter, which is undoubtedly the most convincing proof of the influence of thermal water on the life cycle of spiders. According to Hendrickx and Maelfait (2003), adults of *Pirata piraticus* are present between April and September, reproduction taking place in May–August. We collected a female of *Pirata piraticus* with an egg sac and another with spiderlings in February (air temperature below 0°C) at Livada de Bihor, where the habitat consists of a channel with flowing warm water originating from a factory. Both individuals were caught in the vegetation only about 2 m from the evacuation pipe; the preferred temperature of females with eggs sacs ranges from 26 to 32°C, at least populations studied in Denmark (Nørgaard 1951). Although similar vegetation also exists downstream, it appears that water temperature (28°C at exit from pipe) is too low to maintain a favourable microclimate for the species, as the heated shores are mainly inhabited by *Pardosa* instars. It is likely that *Pirata piraticus* inhabits this moist habitat throughout the year, having a continuous growth and development with adult and immature individuals present all the time and having perhaps two or more generations in a year, but additional studies are required to clarify these issues.

The high number of juveniles and subadults of *Pardosa* and *PiratalPiratula* collected is due to the fact that the species of these genera generally overwinter in immature stages (e.g. Kiss and Samu 2002; Hendrickx and Maelfait 2003). Some studies on winter-active spiders have reported a high number of *Pardosa* instars of different stages present on snow especially in mild weather (Huhta and Viramo 1979; Hågvar and Aakra 2006), where they can arrive from the snow-free patches of ground or climbing along the trunks of woody vegetation (Hågvar and Aakra 2006) from the

overwintering shelters consisting of grass tussocks (Bayram and Luff 1993), leaf litter (Edgar 1971) etc. The individuals from thermal habitats remaining active during the cold season also have an advantage in development compared with overwintering conspecifics because of a longer growing period (Hågvar and Aakra 2006). Even if they do not attain maturity during winter, they feed and grow further and will be the first that become sexually active in spring and reproduce, the larger individuals reproducing at the beginning of the breeding season (Hendrickx and Maelfait 2003).

Taking into account that *Pardosa amentata* generally overwinters in the subadult stage (Jensen et al. 2011) and the species of this genus seem not to reach adulthood in autumn (Kiss and Samu 2002) it is possible that due to the higher temperatures from thermal habitats some individuals of *Pardosa amentata* and *Pardosa proxima*, being active later, moulted and attained sexual maturity at a time when their conspecifics from 'usual' habitats were already/still in dormancy. In an experiment Kiss and Samu (2002) showed that immature instars of *Pardosa hortensis* from autumn, at a temperature of 26°C and long day length, needed an average of 36 days and those of *Pardosa agrestis* an average of 55 days to become mature, whereas in short day length the time period increased to an average of 64 days for the former species and 84 days for the latter. We collected adults of *Pardosa* both at the end of December 2011 and of January 2013, but it is difficult to estimate the moment when maturity is reached because no data are available before December, the sampling being confined to the winter season. Nevertheless, caution is required in interpreting the data because of the low number of captured adults and because occasionally *Pardosa* adults were also collected in winter (Bayram and Luff 1993). On the other hand, it was shown that individuals of *Coelotes atropos* did not moult at temperatures $\leq 6^{\circ}\text{C}$ (Aitchison 1981), so it is highly probable that although the temperature in the vicinity of thermal springs allows spiders to remain active during winter as well, this temperature is still too low to initiate the moulting and maturation of individuals. In addition, development of many spider species is greatly delayed by short photoperiods (Schaefer 1977). However, in certain species, such as *Pirata piraticus*, it was observed that this influence of light is abolished after exposure to cold (Schaefer 1977). Hence, it seems that the combined effects of high temperatures near the hot water, of low temperatures a little further away and of short photoperiods during winter can act differentially on different wolf spider species. The presence of adults of *Arctosa leopardus*, *Trochosa robusta* and *Trochosa ruricola* did not necessarily imply the achievement of an early maturation, being shown that species of these genera can have a life cycle of 2 years, overwintering occurring both in juvenile and adult stages (Bayram 1995; Framenau et al. 1996).

In one way or another all thermal habitats owe their existence to human activities. However, this existence is unstable because sometimes the wells are closed and actions are taken that decrease the flow or temperature of water (Sas et al. 2009; Covaciu-Marcov et al. 2011a), followed by the disappearance of the favourable microhabitats for spiders. In addition, the indispensable vegetation on banks is sometimes destroyed by cattle that graze in the area (case noticed at Chişlaz), resulting in a change in the microclimate (Bell et al. 2001). The spiders become dormant when the favourable microclimate disappears. Such events, which occur intermittently during a winter, also decrease the chance of maturation of spiders.

Although we do not have data on the size of populations, field observations lead us to assume that, at least in some of the investigated habitats the density of wolf

spiders is quite high, considering that they can only be active in a relatively narrow zone of the habitats. High density, existence of individuals of different sizes, and food resources being probably more limited than in the warm season can lead independently or cumulatively to the emergence of intraspecific (Hallander 1970; Samu et al. 1999; Buddle et al. 2003) and interspecific (Gunnarsson 1985) predation. A shortage in food or an inappropriate nutritional composition of prey may also increase the time between moults (Mayntz et al. 2003; Jensen et al. 2011) and can also cause a slight increase in the egg ripening period (Kessler 1971). Therefore, a number of factors can operate in thermal habitats to delay maturation and reproduction of individuals, opening the way to additional studies.

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